

INFLUENCE OF NON-STATIONARY FIELD OF MAGNETOSPHERIC  
CONVECTION ON THE D-REGION

611836

A.Yu.Eliseyev, Yu.V.Kashpar, A.A.Nikitin

58

Research Institute of Physics, Ulyanovskaya ul.1, 198904 Leningrad, USSR.

**INTRODUCTION.** Perturbations of F-region electron density caused by the extension of magnetospheric convection electric field to middle latitudes are already well known (TANAKA and HIRAO, 1973). For the D-region the first observations are believed to be reported by ELISEYEV, KASHPAR and NIKITIN (1988). On several occasions, following the southward turning of the Bz-component of interplanetary magnetic field (IMF) small disturbances of the D-region electron density were detected at night by steep-incidence VLF sounding in Gelendzhik on the Black Sea (ELISEYEV et al, 1988) which may be attributed to the influence of the penetrated convection electric field (CEF). In this paper some evidence is given of a local-time dependence of the CEF effect in the D-region and a rather good correlation is demonstrated at the initial stage of disturbance between high-latitude magnetic field variations and simultaneous perturbation of the midlatitude ionospheric reflection height.

**OBSERVATIONAL TECHNIQUE AND RESULTS.** The abnormal component of the sky-wave VLF field was picked up by a transversal loop aerial at a site in Gelendzhik, about 100 km southward from transmitting station. Midpath invariant latitude is 40 degrees. The VLF-monitoring technique was most similar to that of HOPKINS and REYNOLDS (1954). The CEF search and identification was based on the following selection criteria. Firstly, night-time periods only were considered for there was little hope to detect the CEF-effect at heights as low as 70-75 km by day. Secondly, the wanted disturbance should immediately follow a sudden change of IMF Bz-component preceded by a period of positive Bz, the situation most favourable for CEF penetration into the midlatitude ionosphere. Because of the lack of more detailed information on Bz we had to use its hourly values (COUZENS and KING, 1986). In order to fix more precisely the time of CEF onset, H-magnetograms were used from the high-latitude observatory Abisko (Sweden,  $\Phi=66^\circ$ ). It is believed that variations in high-latitude current system which cause the observed magnetic disturbance at Abisko, are mainly due to changes in the magnetospheric convection (or polar cap) electric field. And finally, it was natural to anticipate simultaneous perturbations both in VLF reflected signal at Gelendzhik and in H-magnetogram at Abisko, at least at the beginning of the disturbance.

The VLF data available for 1976-1980 allowed to select several CEF-events which had occurred after the turning of Bz-component to the south. An example is shown in Fig. 1, where the relative phase  $\Phi_r$  and amplitude  $A_r$  of the abnormal component of the 14.9 KHz signal as received at Gelendzhik are compared to disturbance in H-component of geomagnetic field at Abisko on February 15, 1980. Unfortunately there was a two-hour gap in Bz-data, so it is only possible to say that the polarity change occurred between 1900 UT and 2100 UT, but the H-magnetogram from Abisko implies that the convection electric field started to rise approximately at 2000 UT. This was followed at 2015 UT by a rather abrupt fall of the reflected VLF signal strength and a minor general increase of signal phase lag with superimposed stronger short-period phase oscillations. A burst of phase oscillations at about 2140 UT was accompanied by a similar burst in amplitude variations. The mean quasi-period of phase oscillations between 2020 and 2200 UT appeared to be 13.6 minutes which was lower than the short-period fluctuation quasi-periods before and after the disturbance. Then, 2200 to 2300 UT, relatively small but strikingly synchronous oscillations with a 13.3-minute mean quasi-period could be noticed in VLF phase and geomagnetic field records (Fig. 1 a,b). The maximum peak-to-peak variation of VLF phase reached 38 centicycles (it is equivalent to the 4.8 kilometre range of reflection height variation). The slow component of reflection height rise (in

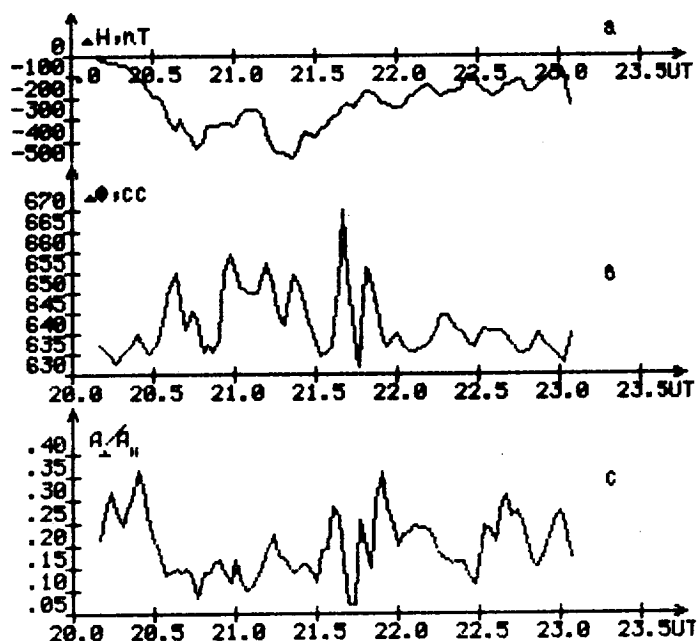


Fig.1

The disturbance of February 15, 1980: a) deviation of the horizontal component of geomagnetic field  $H$  at Abisko, Sweden; b) VLF skywave phase disturbance at Belendzhik ( $h=90$  km corresponds to  $\theta=595$  cc, scaling factor - 0.113 km/cc); c) VLF abnormal component amplitude  $A_A$  relative values  $A_A/A_0$  during the disturbance.

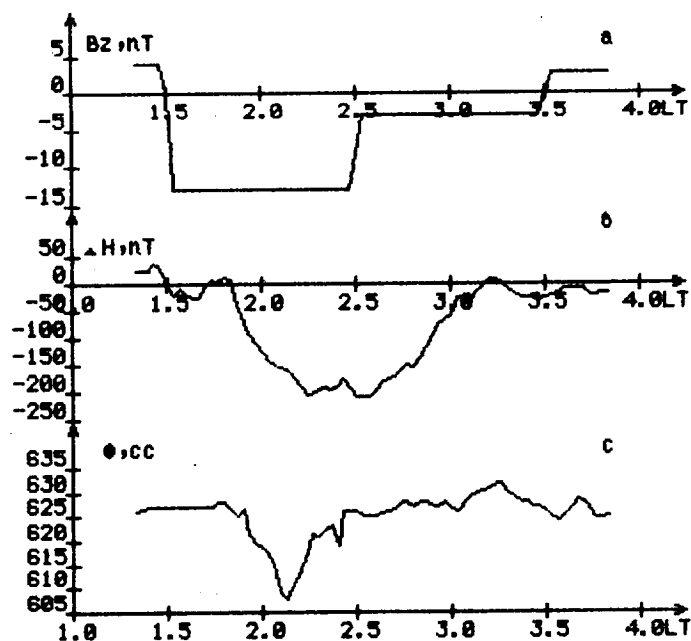


Fig.2

The disturbance of February 25/26, 1980: a) hourly values of the  $B_z$ -component of the IMF; b) the behaviour of the  $H$ -component of geomagnetic field at Abisko, Sweden; c) VLF phase disturbance in Belendzhik.

ORIGINAL PAGE IS  
OF POOR QUALITY

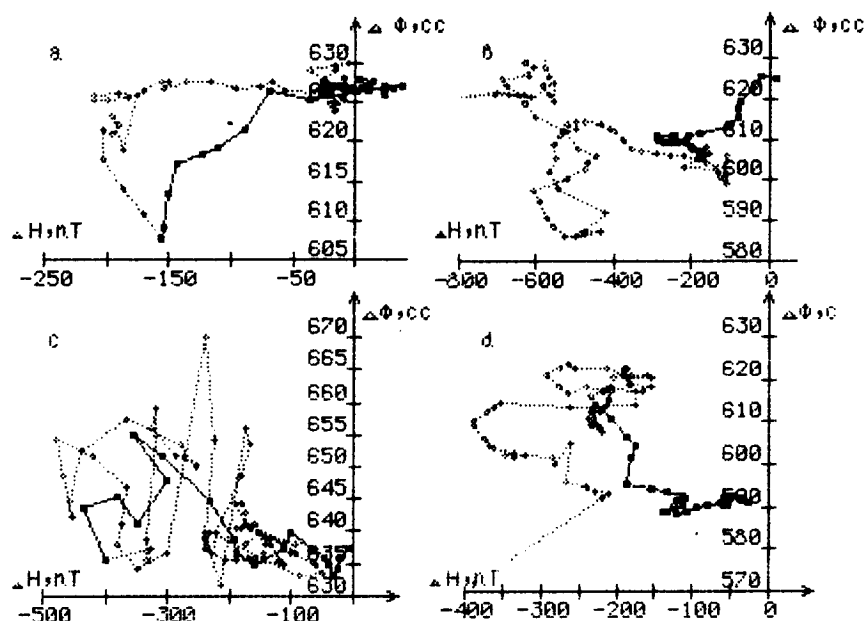


Fig.3

Plots of VLF skywave phase lag  $\Phi$  at Gelendzhik versus geomagnetic H-component at Abisko: a) February 26, 1980 (local date), beginning at 0150 LT of Gelendzhik; b) February 16, 1980, 0320 LT; c) February 15, 1980, 2340 LT; d) January 18, 1978, 0020 LT.

Table

DATE	LT	$A, \text{cc/nT}$	$r$
15.02.1980	2240-2310	-0.047	-0.87
18.01.1978	0030-0100	0.031	0.67
18.01.1978	0100-0130	-0.152	-0.62
26.02.1980	0150-0208	0.107	0.89
26.02.1980	0150-0220	0.052	0.51
16.02.1980	0320-0342	0.058	0.94
16.02.1980	0320-0350	0.037	0.46
16.02.1980	0320-0530	0.118	0.48

terms of the running mean with the averaging interval of 50 minutes) reached its maximum value of about 1 km at 2100 UT. On other occasions there was no substantial increase of the short-period fluctuation intensity at VLF during the CEF-event. Fig.2 shows a CEF-event of February 25/26 1980. A rapid turning of  $B_z$  southward triggered at 2330 UT a high-latitude substorm accompanied by a shorter bay-like lowering of the reflection height (VLF phase lag decrease) at Gelendzhik. It is worth noting that the large negative hourly value of  $B_z$  at 00 UT ( $-16\text{nT}$ ) diminished to  $-3\text{nT}$  at 01 UT. The change of sign of VLF phase perturbation as compared to the disturbance of February 15 may be, presumably, attributed to the local-time variation of CEF.

To illustrate the correlation between a high-latitude magnetic disturbance and a midlatitude ionospheric reflection height perturbation at VLF, plots of VLF phase  $\Phi_1$  variation versus H-component variation are given in Fig.3 for 4 night-time CEF-events which had occurred at different local times. The dots interconnected by straights to show temporal evolution of the event are separated by two-minute intervals. Bold dots and lines represent the first hour of disturbance. The regression coefficients  $A$  for the relation  $\Phi_1 = A \cdot \Delta H + B$  are given in the table for the local dates and time intervals indicated (Gelendzhik local time LT is given). Note that the correlation coefficient  $r$  is used here only as a measure of similarity of two waveforms with no statistical meaning being ascribed to it. Inspection of the table shows that for a sudden onset of disturbance  $|A| = 0.05 \pm 0.1$  with  $|r| \approx 0.9$  and the two quantities decrease as time window broadens. For gradual disturbances (January 18, 1978 and February 16, 1980) both  $|A|$  and  $|r|$  tend to be less sensitive to the window opening and in general  $|A| \approx 0.1 \pm 0.15$  and  $|r| \approx 0.5 \pm 0.6$ .

As for the local-time dependence of the effect in the ionosphere one can suggest that the ionospheric height change tends to be positive before 00 LT and negative after 02 LT, the transition time lying between 0030 and 0130 LT.

**DISCUSSION.** The observed disturbances in the midlatitude night-time D-region seem to be consistent with the idea of magnetospheric convection electric field influence on the electron density at heights of about 90 km, the turning of the  $B_z$  to the south being the necessary condition. Indeed, an example was shown (ELISEYEV et al., 1988), when a substorm which had occurred by positive  $B_z$  had not been accompanied by a disturbance at VLF. If we take the high-latitude magnetic data as a replacement for the data on the penetrated electric field we can say that disturbances in the midlatitude D-region commence simultaneously with the CEF enhancement and correlate rather well with the latter at least within the first 20-40 minutes of the event. Sometimes the short-period oscillations intensify during the disturbance and their quasi-period shortens. A surprisingly good correlation was noticed at the recovery stage of disturbance on February 15, 1980 between the small oscillations of VLF skywave phase lag and those of CEF. A similar behaviour of the short-period fluctuations in the F-region could be seen from the data presented by CROWLEY et al (1984) for a disturbance, which followed the  $B_z$  polarity change. In general, the events described in this paper for the night-time midlatitude D-region have much in common with the well known CEF-events in the thermosphere and hence are likely to have the same origin.

#### REFERENCES

- Couzens, B.A., and J.H. King, Interplanetary medium data book-Supplement 3A, 1977-1985, NASA Goddard Space Flight Center, Greenbelt, Md., 1986.
- Crowley, G., J.R. Dudeney, A.S. Rodger, and T.B. Jones, Large simultaneous disturbances (LSDs) in the Antarctic ionosphere, *J. Atmos. Terr. Phys.*, 46, 917-925, 1984.
- Eliseyev, A.Yu., Yu.V. Kashpar, and A.A. Nikitin, Magnetospheric electric field influence on the midlatitude lower ionosphere, *Geomagnetism i Aeronomia*, 28, 676-679, 1988.
- Hopkins, H.G., and L.G. Reynolds, An experimental investigation of short-distance ionospheric propagation at low and very low frequencies, *Proc. IEE*, Pt3, 101, 21-34, 1954.
- Tanaka, T., and K. Hirao, Effects of an electric field on the dynamical behavior of the ionosphere and its application to the storm time disturbance of the F-layer, *J. Atmos. Terr. Phys.*, 35, 1443-1452, 1973.

## AUTHOR INDEX

	Page		Page
L. Alberca	215	V. F. Laikova	236
J. V. Arkhipov	236	E. M. Larin	104
G. Beig	108	J. Lastovicka	119, 210, 215
J. Boska	230	J. London	9
J. Bremer	196	O. A. Loshkova	92
N. I. Brezgin	104	X.-C. Lu	179
G. M. Brown	53	L. N. Mateev	147, 151
V. Bucha	13	P. E. Meade	129
D. K. Chakrabarty	108	K. Mohanakumar	39, 62
S. Chandra	68	L. P. Morozova	219
M. L. Chanin	27, 33	N. N. Murzaeva	227
M. A. Chernigovskaya	164	B. Narasimhamurty	112
A. F. Chizhov	104	P. I. Nenovski	151
M. Dameris	49	A. A. Nikitin	240
M. Yu. Danilin	82	S. V. Pakhomov	108
A. D. Danilov	183	D. Pancheva	210, 231
B. A. de la Morena	215	J. Pap	9
R. F. Donnelly	1	B. S. N. Prasad	112
A. R. Douglass	129	Z. Ts. Rapoport	215
I. G. Dyominov	117, 118	R. Reiter	168
A. Ebel	49, 116	G. J. Rottman	9
A. Yu. Eliseev	240	G. Satori	192
G. Entzian	43	V. V. Sazonov	104
N. N. Fomina	47	P. H. Scherrer	53
V. A. Gaidukov	164	C. J. E. Schuurmans	22
H. B. Gayathri	112	A. V. Shirochkov	203
L. Hood	76	O. V. Shtirkov	104
I. N. Ivanova	96, 104	N. G. Skryabin	142
C. H. Jackman	129	V. A. Soldatov	236
Yu. V. Kashpar	240	I. I. Sosin	142
E. S. Kazimirovsky	156, 164	J. Taubenheim	43
G. M. Keating	67	B. A. Tinsley	53
P. Keckhut	33	G. A. Tuchkov	117
V. G. Kidiarova	47, 100	A. A. Tyutin	178
G. A. Kokin	104	P. I. Vellinov	147, 151
G. I. Kouznetzov	82	G. von Cossart	43
A. A. Krivolutsky	86, 92, 96	A. M. Zadorozhny	117, 178
L. Krivsky	223	L. V. Zelenkova	236
K. Kudela	135	E. I. Zhovty	164
V. N. Kuznetsova	96, 104	H. C. Zhuang	179